



US009065197B2

(12) **United States Patent**
Powell et al.

(10) **Patent No.:** **US 9,065,197 B2**
(45) **Date of Patent:** **Jun. 23, 2015**

(54) **PROTECTION STRUCTURE FOR
IMPLANTABLE CONNECTOR AND
APPARATUS FOR MANIPULATING SAME**

(71) Applicant: **Cochlear Limited**, Macquarie
University, NSW (AU)

(72) Inventors: **Anthony Powell**, Bondi Junction (AU);
C. Roger Leigh, East Ryde (AU); **James
Dalton**, Beecroft (AU)

(73) Assignee: **COCHLEAR LIMITED**, Macquarie
University, NSW (AU)

(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 60 days.

(21) Appl. No.: **13/851,358**

(22) Filed: **Mar. 27, 2013**

(65) **Prior Publication Data**

US 2014/0273576 A1 Sep. 18, 2014

Related U.S. Application Data

(60) Provisional application No. 61/789,546, filed on Mar.
15, 2013.

(51) **Int. Cl.**
H01R 13/52 (2006.01)
H01R 43/00 (2006.01)
A61N 1/375 (2006.01)

(52) **U.S. Cl.**
CPC **H01R 13/5219** (2013.01); **H01R 43/005**

(2013.01); **Y10T 29/53209** (2015.01); **A61N
1/375** (2013.01); **H01R 2201/12** (2013.01)

(58) **Field of Classification Search**

CPC .. **H01R 13/5219**; **H01R 43/005**; **H01R 13/52**;
H01R 43/00; **H01R 2201/12**; **A61N 1/375**;
Y10T 29/53209
USPC **439/271**, **289**, **909**, **272**, **283**; **29/747**
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,971,057 A 11/1990 Theres
7,844,329 B2 11/2010 Chambers
8,267,708 B1* 9/2012 Sochor 439/289

FOREIGN PATENT DOCUMENTS

WO 2004/097993 11/2004

* cited by examiner

Primary Examiner — Javaid Nasri

(57) **ABSTRACT**

An implantable connector includes: first and second detach-
able mating parts configured to be implantable in living tis-
sue, to terminate first and second segments of a cable, and
have first and second interfacing surfaces, respectively; and a
protection structure configured to protect against contami-
nant intrusion between the first and second interfacing sur-
faces. And a device for decoupling and re-coupling the
detachable mating parts in an environmentally controllable
volume is provided.

23 Claims, 13 Drawing Sheets

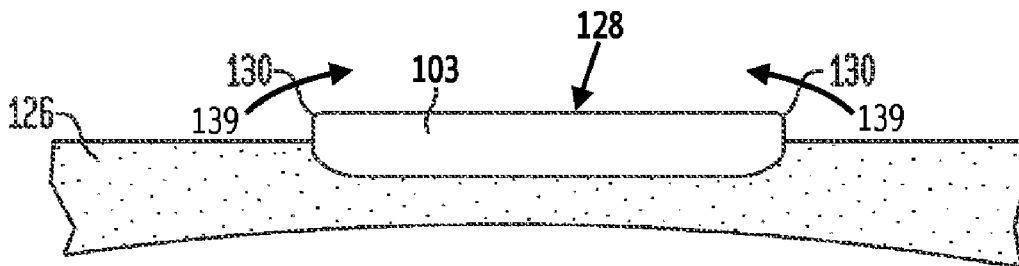


FIG. 1A

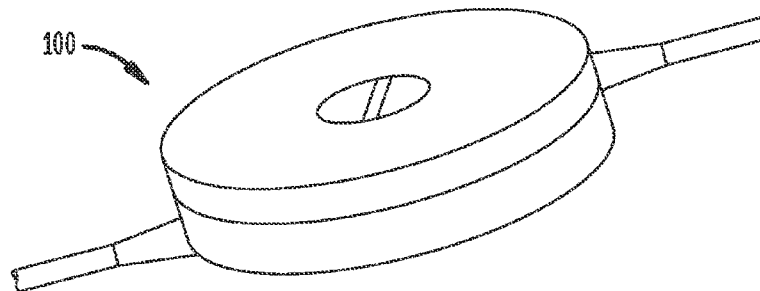


FIG. 1B

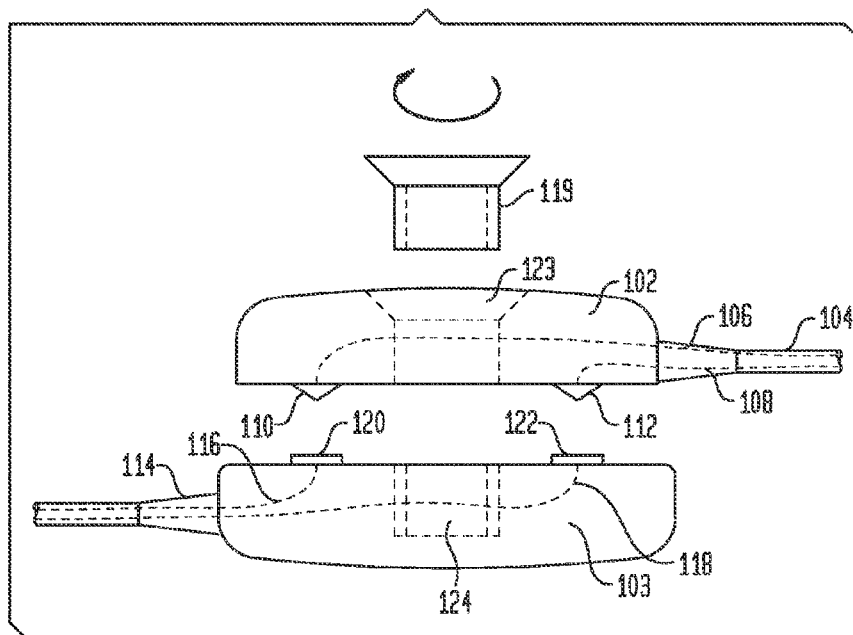


FIG. 1D

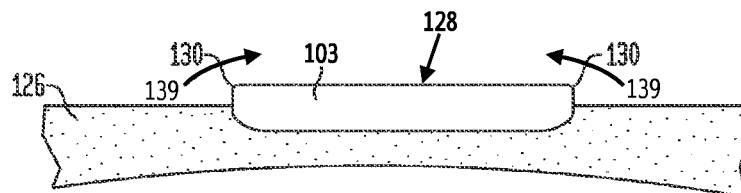


FIG. 1C

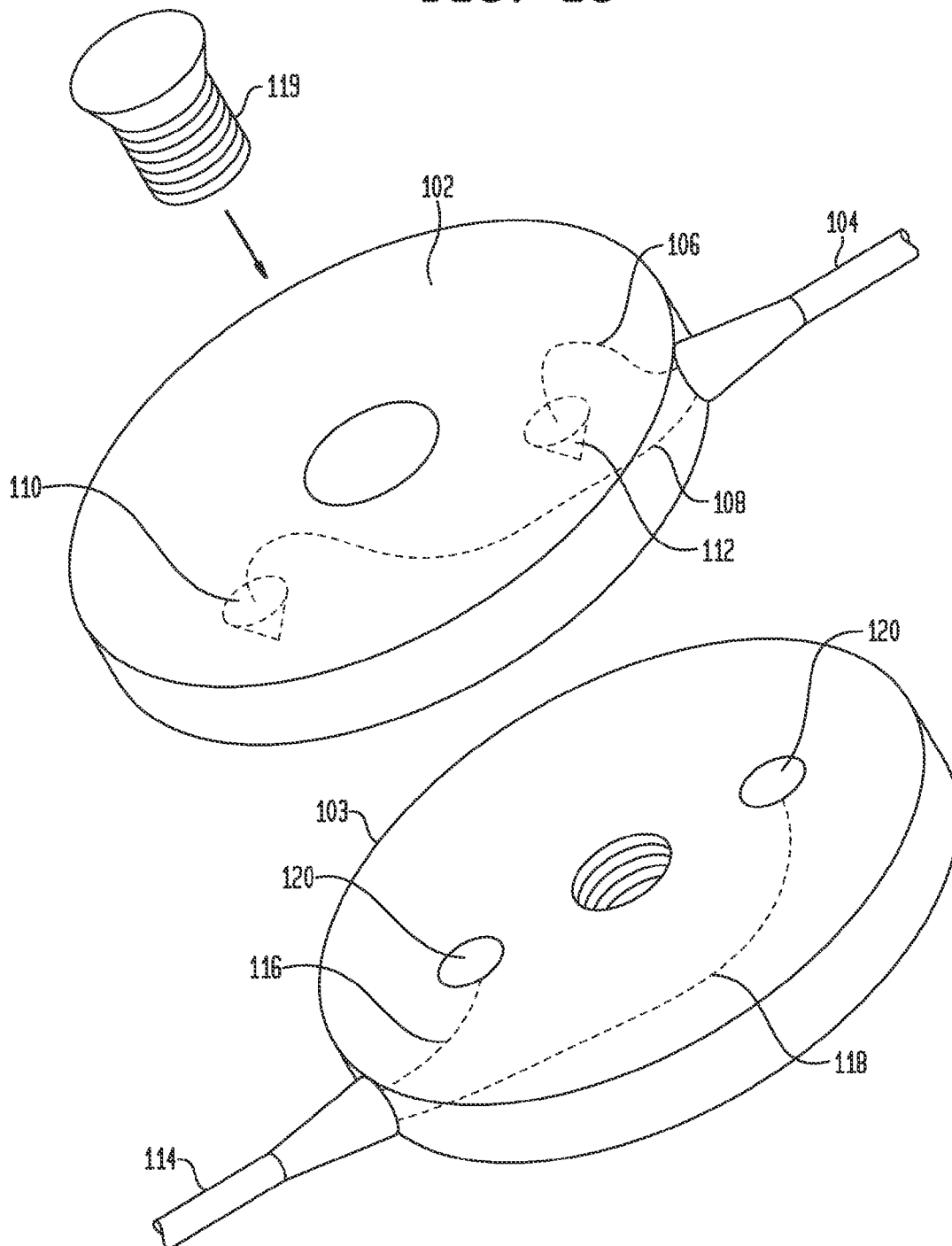


FIG. 2A

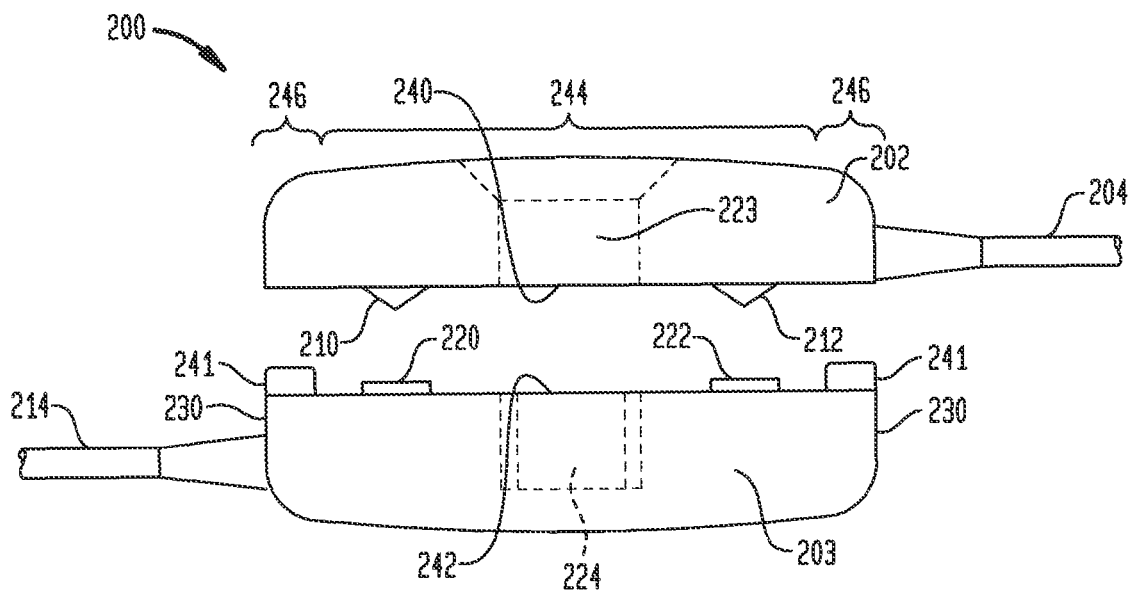
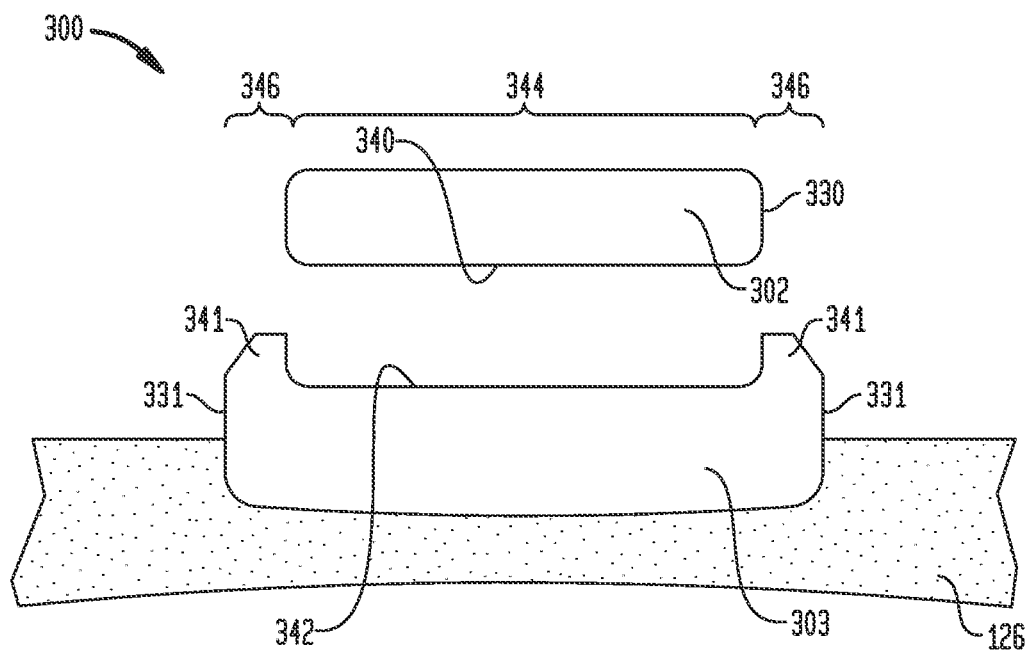


FIG. 2B



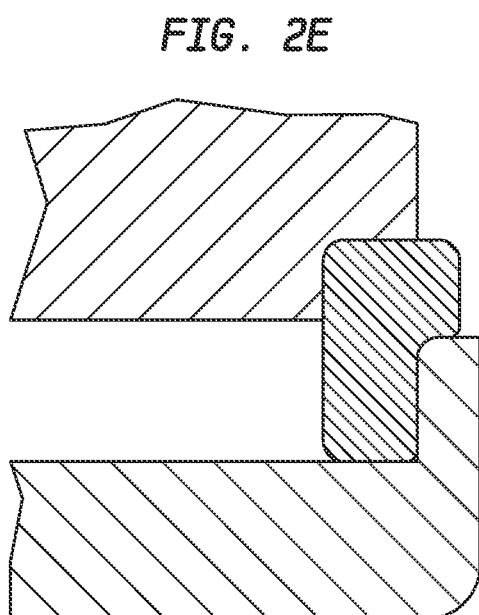
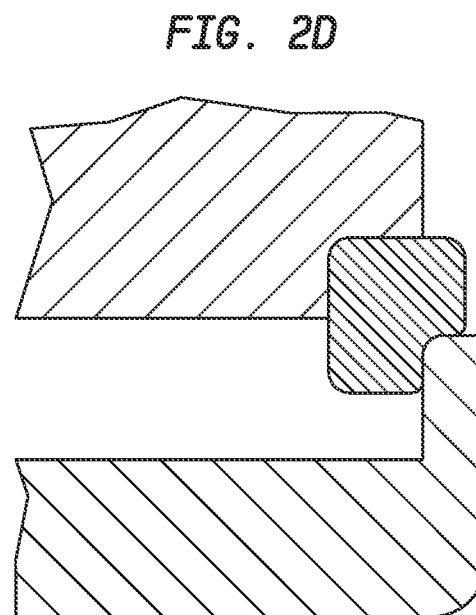
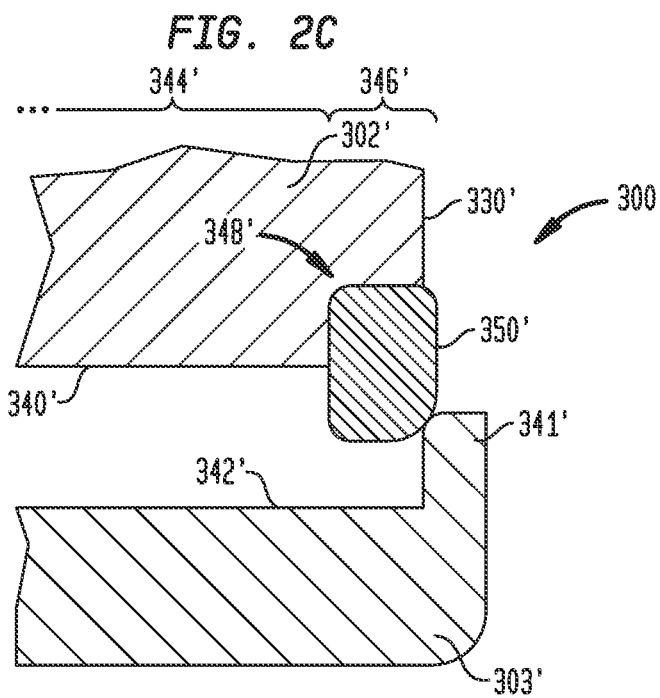


FIG. 2F

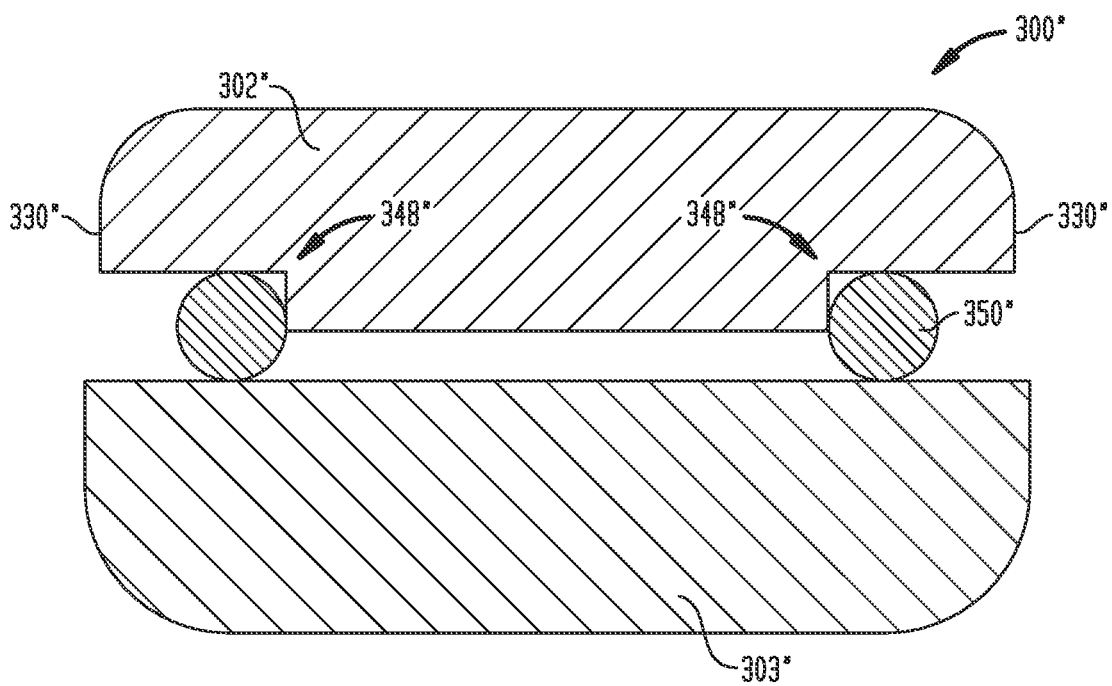


FIG. 2G

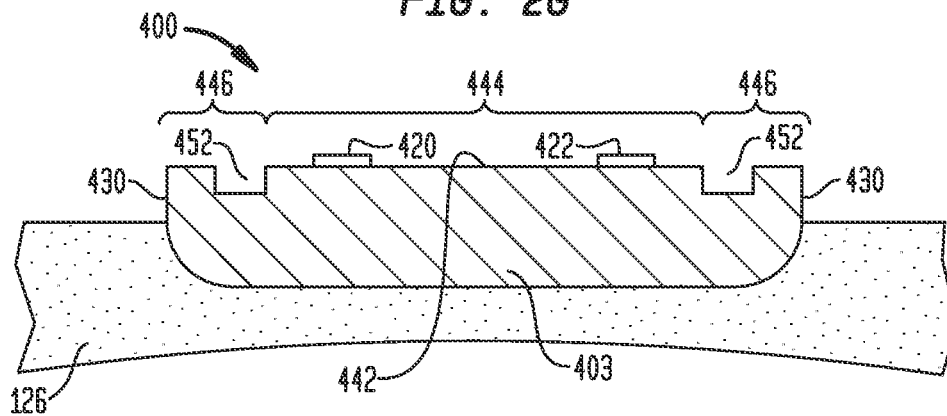


FIG. 2H

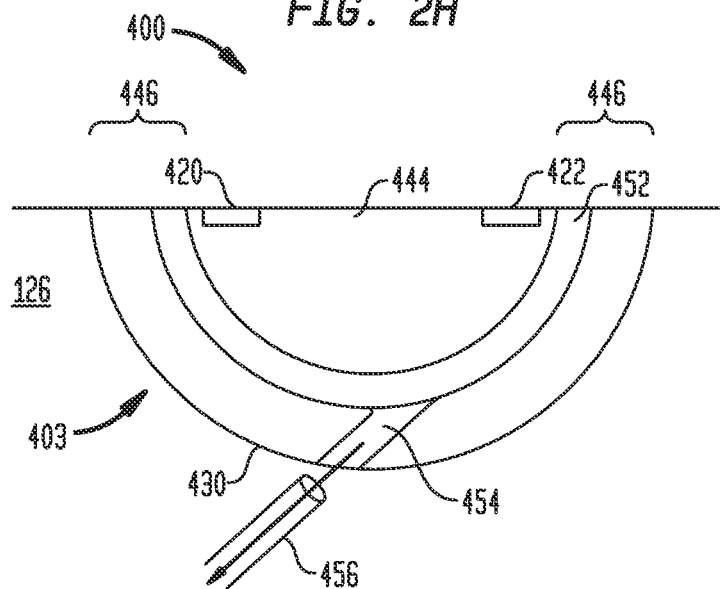


FIG. 3A

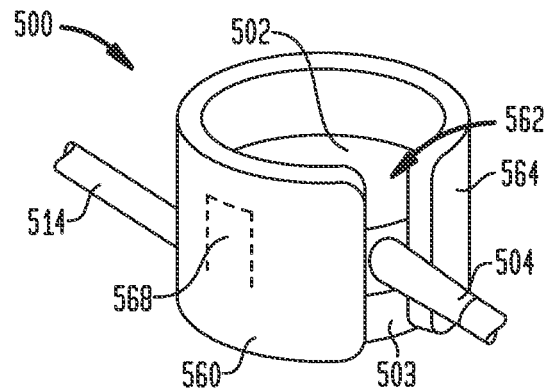


FIG. 3B

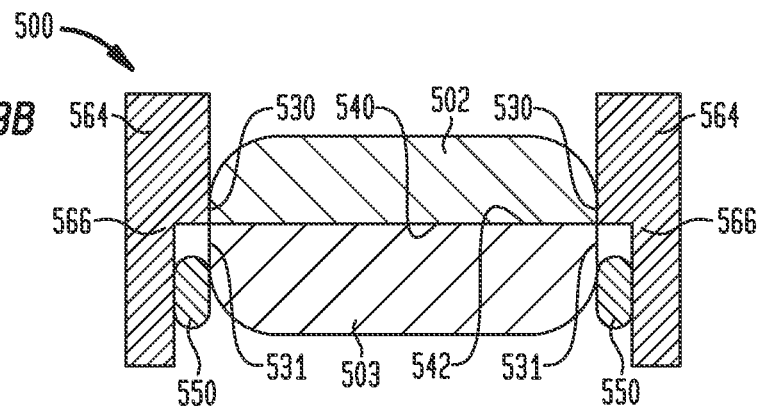


FIG. 3C

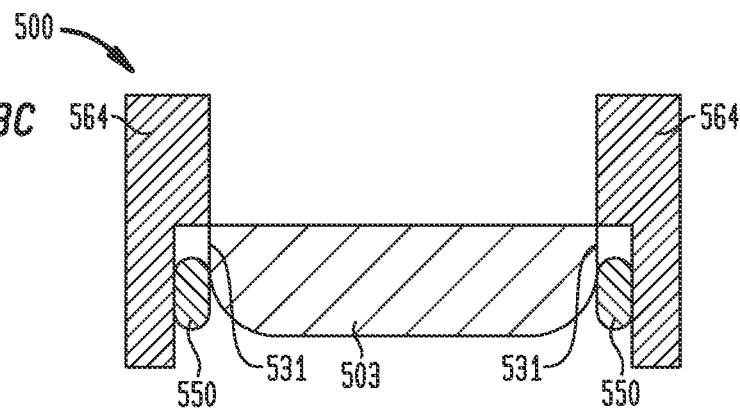
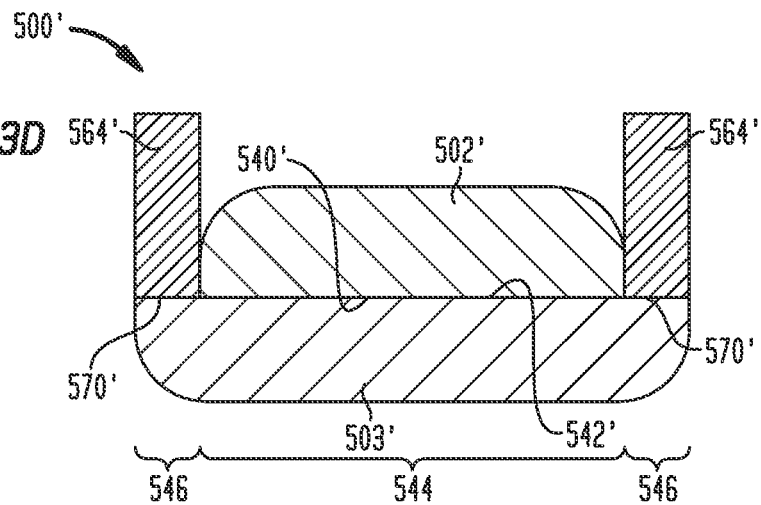


FIG. 3D



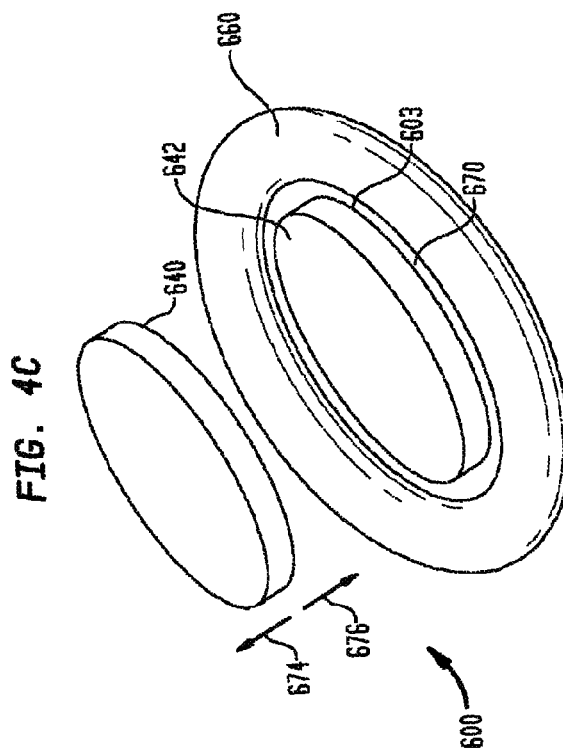
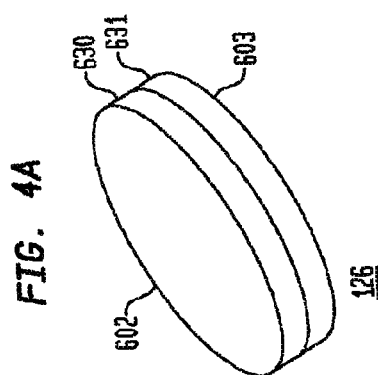
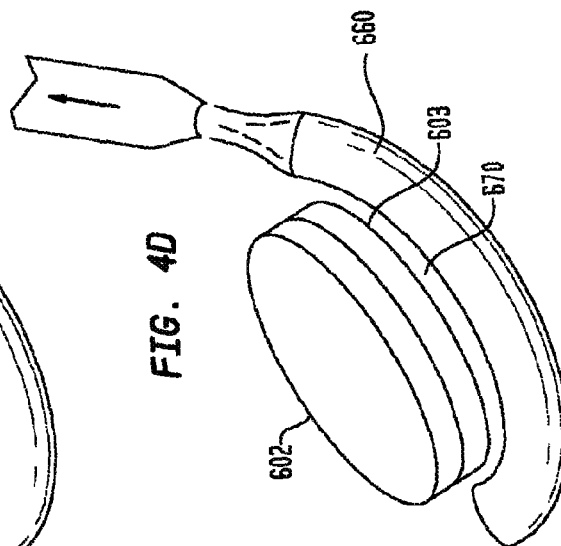
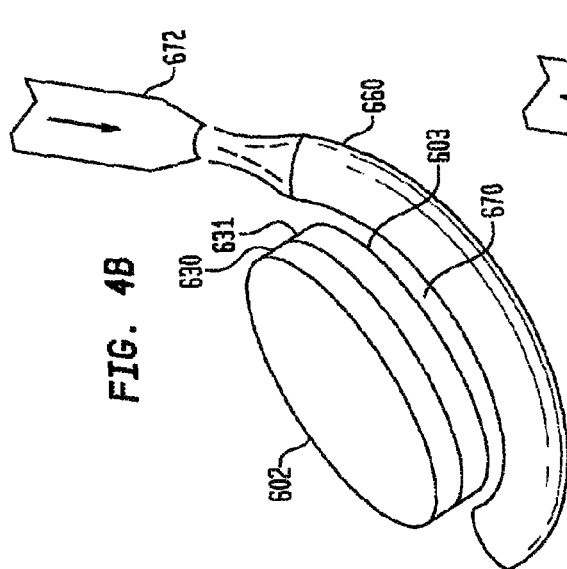


FIG. 5A

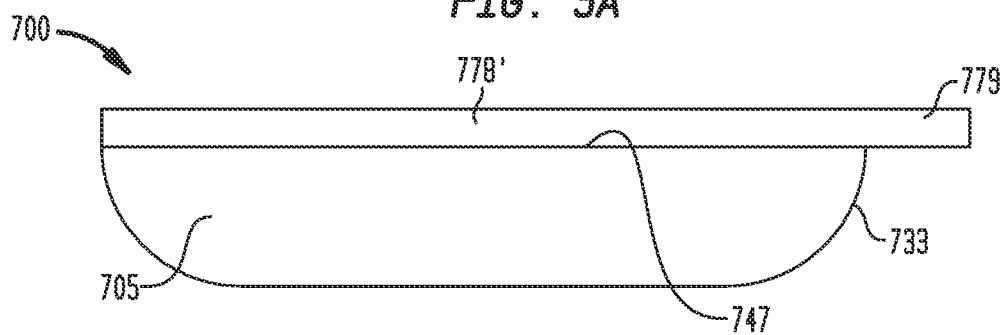


FIG. 5B

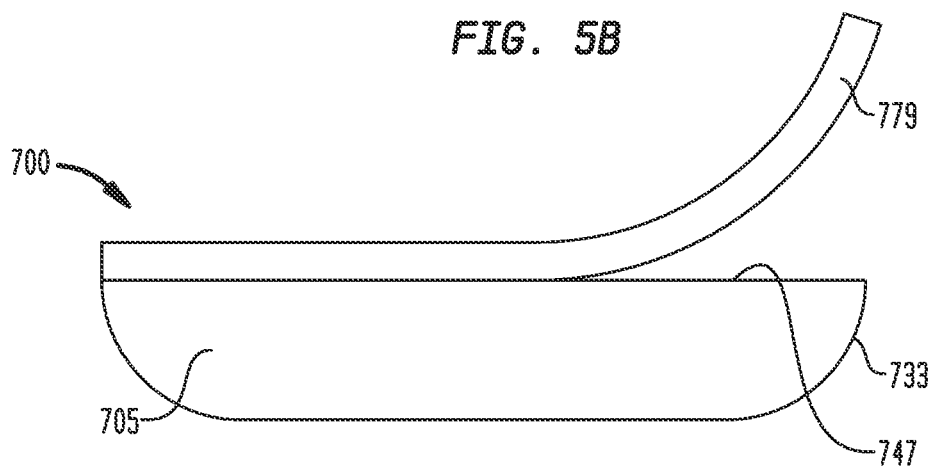


FIG. 6A

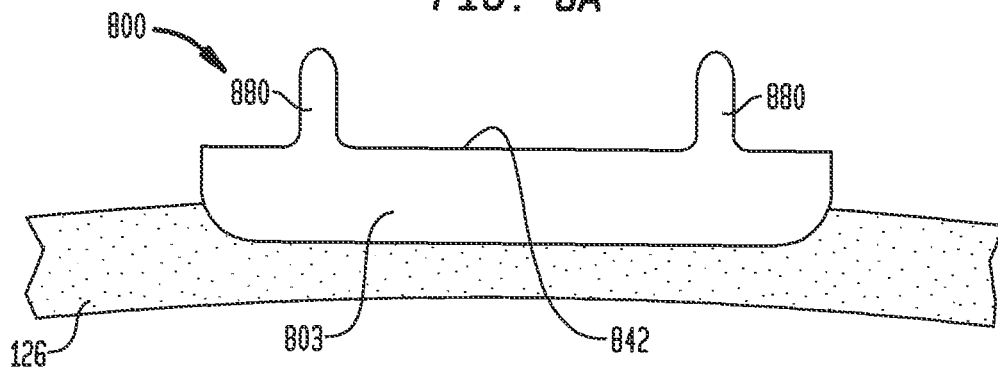


FIG. 6B

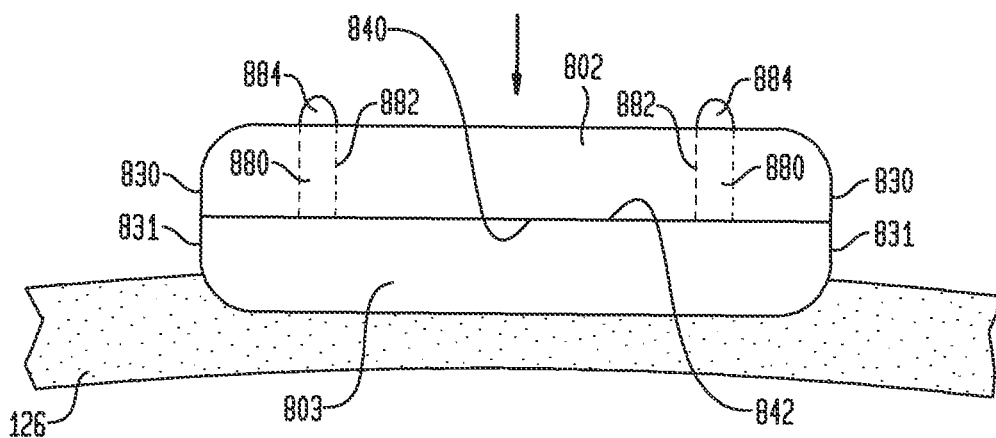


FIG. 6C

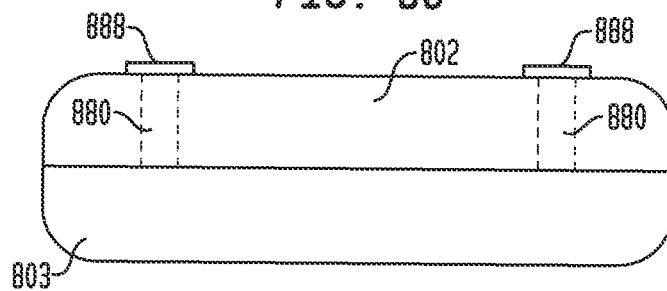


FIG. 7A

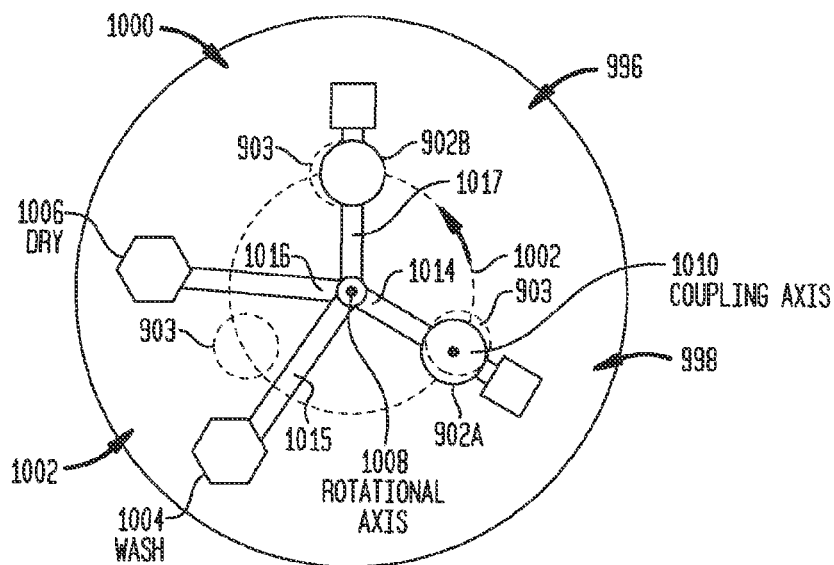
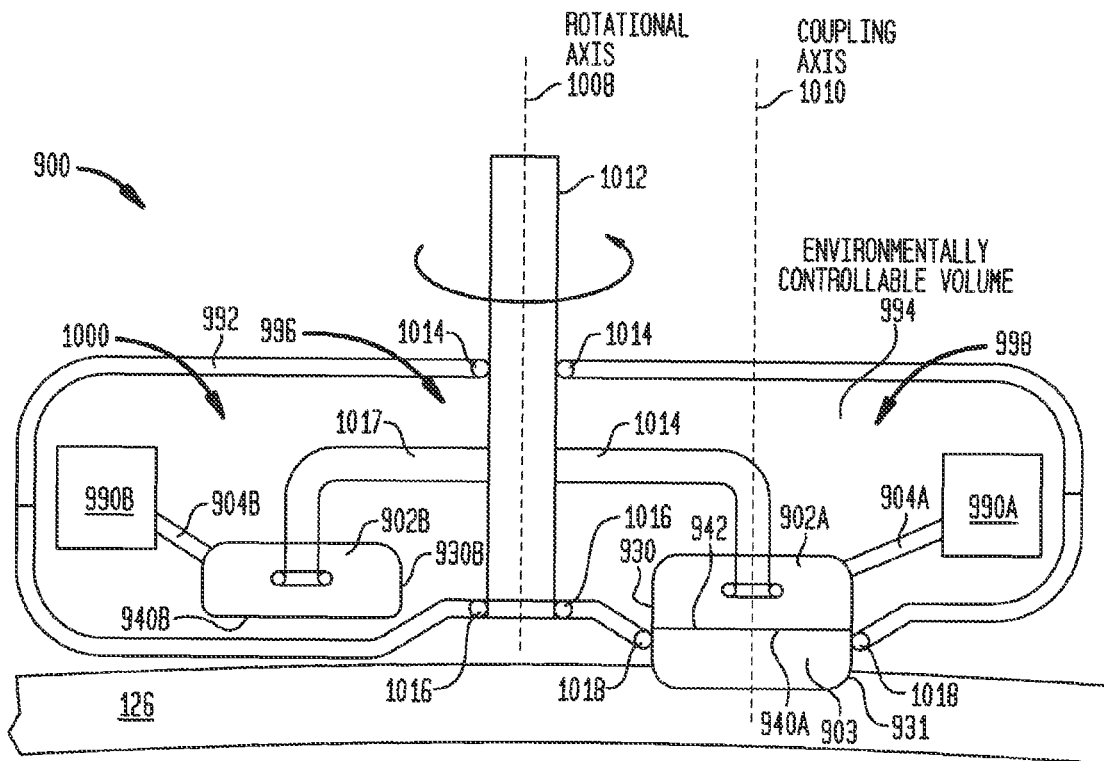
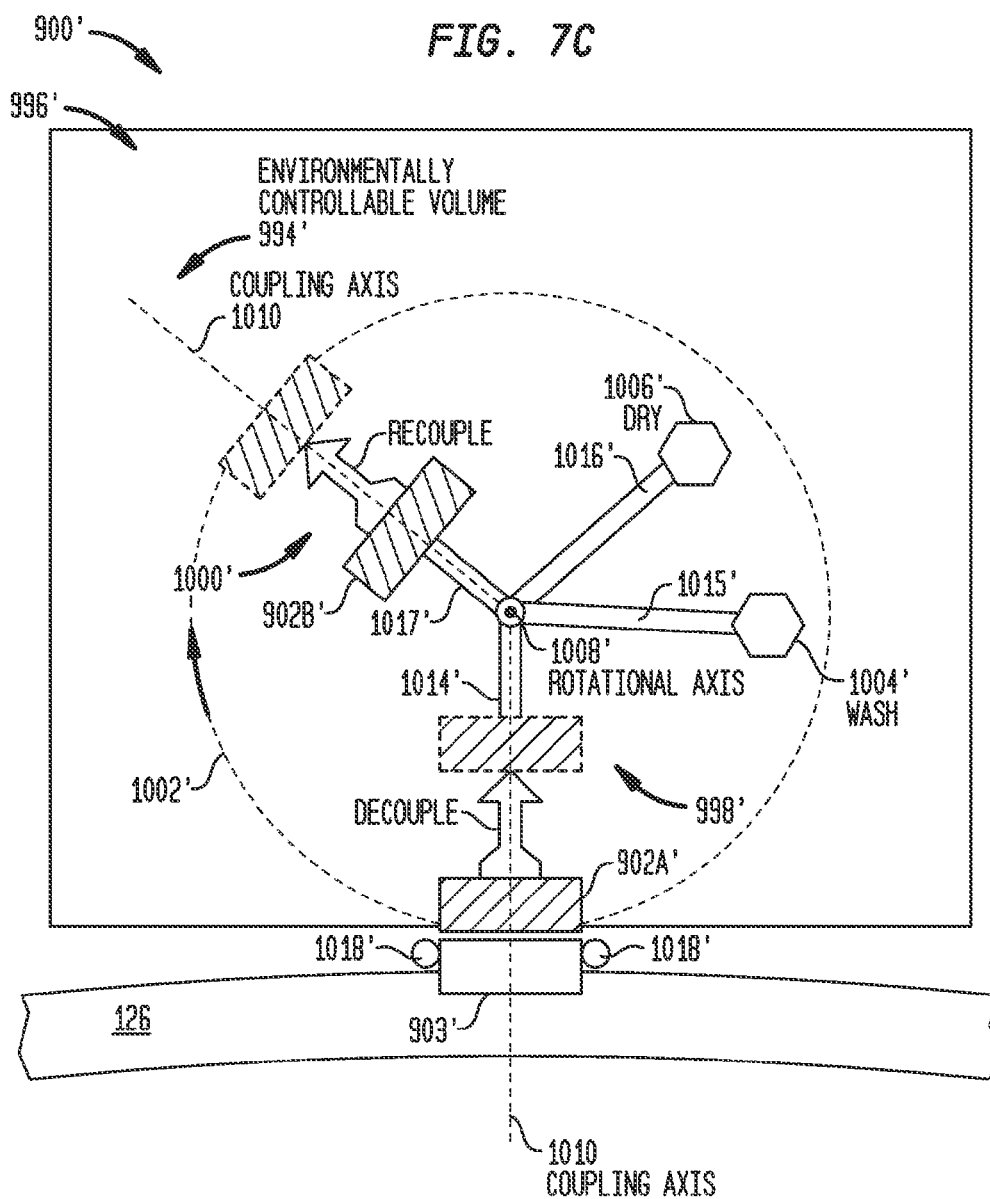


FIG. 7B





1

PROTECTION STRUCTURE FOR IMPLANTABLE CONNECTOR AND APPARATUS FOR MANIPULATING SAME

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims the benefit of U.S. Provisional Patent Application No. 61/789,546, filed Mar. 15, 2013. The content of this application is hereby incorporated by reference herein.

BACKGROUND

1. Field of the Disclosure

The present technology relates generally to detachable mating parts of an implantable connector that terminate segments of a cable, and to a device for manipulating detachment and/or re-attachment of such mating parts.

2. Related Art

Implantable medical devices often have more than one implantable component. Such components are typically connected by one or more cables through which the components communicate, transfer data and/or transfer power. Such a cable typically comprises one or more electrical conductors and is configured with a segment that terminates with a mating part of an implantable connector. The detachable mating parts of the connector facilitate replacement of device components when such components fail, are consumed, or are in need of being updated. For example, an implantable connector on a device requiring an implanted battery facilitates replacement of the battery.

For some implantable connectors, it is important to exclude body fluids from the mating surfaces of the mating parts. Body fluids are ionic, which can cause current leakage between the conductors in the short term. In the long term, ionic body fluids may precipitate dendritic growth between the mating surfaces, which can contribute to device failure.

On the occasion of decoupling and re-coupling the detachable mating parts of such a connector in a surgical environment where body fluids present exposure of the mating surfaces of the mating parts to the bodily fluids is a risk.

SUMMARY

In one aspect of the present technology an implantable connector is provided. The implantable connector includes: first and second detachable mating parts and a protection structure. The first and second mating parts are configured: to be implantable in living tissue; to terminate first and second segments of a cable; and have first and second interfacing surfaces, respectively. The protection structure is configured to protect against contaminant intrusion between the first and second interfacing surfaces.

In another aspect of the present technology, a system for protecting an implantable connector is provided. The connector to be protected has first and second detachable mating parts configured to be implantable in living tissue and terminate first and second segments of a cable, each mating part having an interfacing surface bounded by one or more sidewalls. Such a system includes: a protection structure configured to enclose the one or more sidewalls of at least one of the first and second mating parts.

In yet another aspect of the present technology, a system for protecting a mating part of an implantable connector is provided. Such a system includes: a first detachable mating part; and a protection structure. The mating part is configured

2

to: be implantable in living tissue; terminate a segment of a cable; have an interfacing surface; and engage with a corresponding second detachable, implantable mating part. The protection structure is configured to protect the interfacing surface against contamination.

In yet another aspect of the present technology, an implantable connector is provided. Such a connector includes first and second detachable mating parts. Each mating part is configured: to be implantable in living tissue; to terminate first and second segments of a cable; and to have first and second interfacing surfaces, respectively. The first mating part includes: at least one alignment projection extending substantially perpendicularly from the first interfacing surface. The second mating part includes at least one alignment hole corresponding to the at least one alignment projection, respectively. Each alignment hole is complementarily shaped to receive the corresponding alignment projection.

In yet another aspect of the present technology, there is provided a machine for manipulating first and second detachable mating parts of an implantable connector that terminate first and second segments of a cable. Such a machine includes: an enclosure configured to releasably enclose at least the second mating part and a portion of the first mating part in an environmentally controllable volume; and a coupling device configured to at least one of decouple and re-couple the first and second mating parts, respectively, while the second mating part and the portion of the first mating part are disposed in the environmentally controllable volume.

BRIEF DESCRIPTION OF THE DRAWINGS

Embodiments of the present technology are described below with reference to the attached drawings, in which:

FIG. 1A is a three-quarter perspective view, FIG. 1C is an exploded three-quarter perspective view, and FIGS. 1B and 1D are cross-sections (FIG. 1D being relatively simplified), of an implantable connector;

FIG. 2A is an exploded side view of an implantable connector in which some embodiments of the present technology may be implemented;

FIG. 2B is an exploded cross-section of another implantable connector in which some embodiments of the present technology may be implemented;

FIGS. 2C-2E are exploded partial cross-sections of another implantable connector 300' in which some embodiments of the present technology may be implemented;

FIG. 2F is a cross-section of another implantable connector in which some embodiments of the present technology may be implemented;

FIG. 2G is a cross-section, and FIG. 2H is a top view of one-half, of a mating part of another implantable connector in which some embodiments of the present technology may be implemented;

FIG. 3A is a three-quarter perspective view, and FIGS. 3B-3C are cross-sections, of a system, in which some embodiments of the present technology may be implemented, for protecting an implantable connector against contaminant intrusion between mating parts of the connector;

FIG. 3D is a cross-section of another system, in which some embodiments of the present technology may be implemented, for protecting an implantable connector against contaminant intrusion between mating parts of the connector;

FIGS. 4A-4D are cross-sections that together illustrate another system in which some embodiments of the present technology may be implemented, for protecting an implantable connector against contaminant intrusion between mating parts of the connector;

3

FIGS. 5A-5B are cross-sections of another system in which some embodiments of the present technology may be implemented, the system being for protecting a mating part of an implantable connector against contaminant intrusion;

FIGS. 6A-6C are cross-sections of another connector in which some embodiments of the present technology may be implemented.

FIG. 7A is a top view, and FIG. 7B is a cross-section, of a machine in which some embodiments of the present technology may be implemented, the machine being for manipulating mating parts of an implantable connector; and

FIG. 7C is a cross-section of another machine in which some embodiments of the present technology may be implemented, the machine being for manipulating mating parts of an implantable connector.

DETAILED DESCRIPTION

Aspects of the present technology relate to an implantable connector including: first and second detachable mating parts; and a protection structure configured to protect against contaminant intrusion between the first and second interfacing surfaces of the first and second mating parts. Without the protection structure, the interfacing surfaces are otherwise at risk of contamination, e.g., on the occasion of decoupling and/or re-coupling the detachable mating parts in a surgical environment where body fluids present, e.g., in a context of replacing an expired battery, exposure of the mating surfaces of the mating parts to the bodily fluids is a risk.

Another aspect of the present technology relates to a system for protecting an implantable connector having first and second detachable mating parts configured to be implantable in living tissue and terminate first and second segments of a cable. Each mating part has an interfacing surface bounded by one or more sidewalls. The system includes a protection structure configured to enclose the one or more sidewalls of at least one of the first and second mating parts. For example, the protection structure can include a hollow cylinder configured to abuttingly enclose at least the one or more sidewalls of the second mating part. As another example, the protection structure can be a coffer dam disposed on the tissue and configured to enclose at least the one or more sidewalls of the second mating part.

Another aspect of the present technology relates to another protection structure configured to protect the interfacing surface against contamination, e.g., by taking the form of a removable layer of material disposed in contact with the interfacing surface so as to seal the same from the ambient environment. Such a removable layer protects the interfacing surface until the mating part is ready for coupling to a counterpart mating part, at which time the person intending to couple the mating parts, e.g., a surgeon, can remove the removable layer of material.

Another aspect of the present technology relates to an implantable connector including first and second detachable mating parts. The first mating part includes at least one alignment projection extending substantially perpendicularly to the first interfacing surface. The second mating part includes at least one alignment hole corresponding to the at least one alignment projection, respectively. Each alignment hole is complementarily shaped to receive the corresponding alignment projection. Each alignment projection, e.g., can include: a first portion extending from the first interfacing surface into the recess; and a second portion standing proud of the corresponding second surface of the second mating part. The proud-standing portion of each alignment projection, e.g.,

4

can be configured as a flange that resists a tendency (if any) for the mating parts to decouple.

Another aspect of the present technology relates to a machine for manipulating first and second detachable mating parts of an implantable connector that terminate first and second segments of a cable. Such a machine includes: an enclosure configured to releasably enclose at least the second mating part and a portion of the first mating part in an environmentally controllable volume; and a coupling device configured to at least one of decouple and re-couple the first and second mating parts, respectively, while the second mating part and the portion of the first mating part are disposed in the environmentally controllable volume.

The coupling device includes, e.g., a decoupling apparatus and a re-coupling apparatus. During the operation of the machine, the first mating part is stationary relative to instances of the second mating part. The decoupling apparatus is configured to: decouple the first mating part and a first instance of the second mating part; and move the first instance of the second mating part along an arcuate path away from the first mating part. The re-coupling apparatus is configured to: move a second instance of the second mating part along the arcuate path towards the first mating part; and re-couple the first mating part to the second instance of the second mating part. There is a rotational axis about which the motion along the arcuate path occurs. And there is a coupling axis associated with the motions of decoupling and re-coupling. The coupling axis is either substantially orthogonal or substantially parallel to the rotational axis.

FIG. 1A is a three-quarter perspective view of an implantable connector **100**. FIG. 1B is an exploded side view of connector **100**. And FIG. 1C is an exploded three-quarter perspective view of implantable connector **100**.

Implantable connector **100** is a button type of connector that includes: a first detachable mating part **102** and a second detachable mating part **103** corresponding thereto. Mating parts **102** and **103** terminate a first segment **104** and a second segment **114** of a cable. In FIGS. 1B-1C, the cable is illustrated as including first and second signal lines, the first signal line including segments **106** and **116**, the second signal line including segments **108** and **118**. Signal line segments **106** and **108** are connected to electrodes **110** and **112**, respectively, and signal line segments **116** and **118** are connected to electrodes **120** and **122**, respectively. It is noted that fewer and greater numbers of signal lines and corresponding electrodes are contemplated. On any given signal line, various signals are contemplated as being conducted, e.g., power, data, control, communication, etc., respectively. While electrodes **110** and **112** are illustrated as having triangular cross sections, and electrodes **120** and **122** are illustrated as having rectangular cross sections, other shapes are contemplated for the electrodes. While illustrated as being a button type, other types of connectors are contemplated for connector **100**. The various components of connector **100** are formed of biocompatible materials, e.g., including one or more of Titanium, Silicone, Ceramic, Platinum, Platinum/Iridium, polyether ether ketone (PEEK), etc.

Connector **100** also includes, for example, a frictional engaging member **119**, e.g., a screw, that can be inserted through a corresponding through-hole (e.g., unthreaded) **123** in mating part **102** and into a corresponding complementarily-shaped frictional engaging recess **124**, e.g., a threaded hole, in mating part **103**. When inserted through through-hole **123** into hole **124**, screw **119** applies a force to mating part **102** that urges mating part **102** to abut mating part **103**, i.e., urges mating part **102** to couple with mating part **103**. More particularly, the force applied by screw **119** urges electrodes

5

110 and 112 to abut and thus to connect to electrodes 120 and 122, respectively. The force applied by screw 119 also resists a tendency of mating parts 102 and 103 to decouple. In addition, holes 123 and 124 are formed in alignment so that the insertion of screw 119 causes mating parts 102 and 103 to align, thereby facilitating good electrical connections between corresponding electrodes 110 and 120, and corresponding electrodes 112 and 122.

FIG. 1D illustrates one of mating parts 102 and 103, e.g., 103, implanted in bone 126, e.g., in the midst of a surgical procedure, e.g., a procedure to replace an instance of mating part 102 ("replacee mating part 102") by another instance of mating part 102 ("replacer mating part 102") while mating part 103 remains in its implanted position. When replacee mating part 102 is decoupled from mating part 103, a surface 128 of mating part 103 on which the electrodes are located is placed at risk of contamination by body fluids that wash over sidewalls 130 of mating part 103. Mating parts 102 and 103 also can begin in a decoupled state before they are initially coupled (e.g., such as when mating part 103 is implanted albeit before being initially coupled with mating part 102), during which time surface 128 of mating part 103 is similarly at risk of contamination by body fluids that wash/seep/migrate over sidewalls 130 as shown by arrows 139.

FIG. 2A is an exploded side view of an implantable connector 200 in which some embodiments of the present technology may be implemented. Connector 200 is similar in many respects to connector 100 of FIGS. 1A-1C, as indicated by similar numbering.

Implantable connector 200, e.g., a button type of connector, includes: a first detachable mating part 202 and a second detachable mating part 203 corresponding thereto. Mating parts 202 and 203 terminate a first segment 204 and a second segment 214 of a cable, respectively. In FIG. 2A, the cable includes first and second signal lines (not illustrated). Segments (not illustrated) of the first signal line are connected to electrodes 210 and 212, respectively. Segments (not illustrated) of the second signal line are connected to electrodes 220 and 222, respectively. It is noted that fewer and greater numbers of signal lines and corresponding electrodes are contemplated. On any given signal line, various signals are contemplated as being conducted, e.g., power, data, control, communication, etc., respectively. While electrodes 210 and 212 are illustrated as having triangular cross sections, and electrodes 220 and 222 are illustrated as having rectangular cross sections, other shapes are contemplated for the electrodes. While illustrated as being a button type, other types of connectors are contemplated for connector 200. The various components of connector 200 are formed of biocompatible materials, e.g., including one or more of Titanium, Silicone, Ceramic, Platinum, Iridium, polyether ether ketone (PEEK), etc.

Connector 200 also includes, for example, a frictional engaging member (not illustrated), e.g., a screw, that can be inserted through a corresponding through-hole (e.g., unthreaded) 223 in mating part 202 and into a corresponding complementarily-shaped frictional engaging recess 224, e.g., a threaded hole, in mating part 203. When inserted through through-hole 223 into hole 224, the screw applies a force to mating part 202 that urges mating part 202 to abut mating part 203, i.e., urges mating part 202 to couple with mating part 203. More particularly, the force applied by the screw urges electrodes 210 and 212 to abut and thus to connect to electrodes 220 and 222, respectively. The force applied by the screw also resists a tendency of mating parts 202 and 203 to decouple. In addition, holes 223 and 224 are formed in alignment so that the insertion of the screw causes mating parts 202

6

and 203 to align, thereby facilitating good electrical connections between corresponding electrodes 210 and 220, and corresponding electrodes 212 and 222.

Mating parts 202 and 203 of connector 200 have interfacing surfaces 240 and 242, respectively. Each of interfacing surfaces 240 and 242 is arranged with an inner area 244, e.g., a circular area, enclosed by an outer area 246, e.g., an annular outer area. Electrodes 210, 212, 220 and 222 are provided on inner areas 244, and corresponding electrodes 212 and 222.

In FIG. 2A, mating parts 202 and 203 are illustrated in a decoupled state. As noted, e.g., a decoupled state can arise in the context of a surgical procedure, e.g., a procedure to replace an instance of mating part 202 ("replacee mating part 202") by another instance of mating part 202 ("replacer mating part 202") while mating part 203 remains in its implanted position, e.g., implanted in bone, or mating parts 202 and 203 can begin in a decoupled state before they are initially coupled, etc. Assuming the replacement scenario for the purposes of discussion, when replacee mating part 202 is decoupled from mating part 203, interfacing surface 242 of mating part 203 on which electrodes 220 and 222 are located is placed at risk of contamination by body fluids that wash over sidewalls 230 of mating part 203.

To protect against such a risk, connector 200 further includes a protection structure 241, e.g., a wall, projecting from interfacing surface 242 and configured to protect interfacing surfaces 240 and 242 against contaminant intrusion. Wall 241 is formed on, e.g., outer area 246 of interfacing surface 242, and can align with sidewalls 230 or be located inward thereof. Wall 241 is configured to enclose inner areas 244 of interfacing surfaces 240 and 242. While mating parts 202 and 203 are decoupled, wall 241 protects inner area 244 of interfacing surface 242, and thus electrodes 220 and 222, from contamination by body fluids that otherwise might wash over sidewalls 230 of mating part 203. When mating part 202 is coupled to mating part 203, wall 241 is of sufficient height (equal to or greater than the combined heights of electrodes 210 and 220, and 212 and 222, respectively) so that wall 241 forms a seal between mating parts 202 and 203. Wall 241 can be formed of the same material as mating part 203. Alternatively, wall 241 can be formed of a relatively more resilient material, or a foam or viscous material, that deforms upon compression to enhance the seal made by wall 241 against outer surface 246 of interfacing surface 240. Alternatively, wall 241 can have a counterpart wall (not illustrated) formed on outer area 246 of interfacing surface 240 of mating part 202 in addition to (or instead of) wall 241. For example, wall 241 and counterpart wall can be aligned with each other similar to how the electrode pairs are aligned.

FIG. 2B is an exploded cross-section of another implantable connector 300 in which some embodiments of the present technology may be implemented. Connector 300 is similar in many respects to connector 200 of FIG. 2A, as indicated by similar numbering, and in some respects has been illustrated in less detail for the sake of brevity.

Mating parts 302 and 303 of connector 300 have interfacing surfaces 340 and 342, respectively. Each of interfacing surfaces 340 and 342 is arranged with an inner area 344, e.g., a circular area, and interfacing surface 342 is arranged with an outer area 346, e.g., an annular outer area, that encloses inner area 344 of interfacing surface 342. Corresponding electrode pairs (not illustrated) are provided on inner areas 344 of interfacing surfaces 340 and 342.

In FIG. 2B, mating parts 302 and 303 are illustrated in a decoupled state, and the replacement scenario is assumed for the purposes of discussion. Connector 300 further includes a protection structure 341, e.g., a skirt or apron, projecting from

interfacing surface **342** and configured to protect interfacing surfaces **340** and **342** against contaminant intrusion. Skirt **341** is formed on, e.g., outer area **346** of interfacing surface **342**, and can be described as an extension of sidewalls **331**.

Skirt **341** is configured to enclose inner areas **344** of interfacing surfaces **340** and **342**. While mating parts **302** and **303** are decoupled, skirt **341** protects inner area **344** of interfacing surface **342**, and thus the electrodes formed thereon, from contamination by body fluids that otherwise might wash over sidewalls **330** of mating part **303**. Together, skirt **341** and inner area **344** of interfacing surface **342** define a recess in mating part **303**. Mating part **302** is configured in the shape of a complementary projection sized to engage the recess.

FIGS. 2C-2E are exploded partial cross-sections of another implantable connector **300'** in which some embodiments of the present technology may be implemented. Connector **300'** is similar in many respects to connector **300** of FIG. 2B, as indicated by similar numbering, and in some respects has been illustrated in less detail for the sake of brevity.

Mating part **302'** is formed with a notch **348** between interfacing surface **340'** and sidewall **330'**. As such, for interfacing surface **340'**, inner area **344'** stands proud of outer area **346'** of interfacing surface **340'**. In connector **300'**, the protection structure not includes skirt **341'** but also includes a gasket **350'**, e.g., an o-ring. FIGS. 2A-2C illustrate mating part **302'** being inserted progressively further into the recess formed by interfacing surface **342'** and skirt **341'**, respectively. Gasket **350** can be formed of a resilient material, a foam material or a viscous material, that deforms upon compression.

FIG. 2F is a cross-section of another implantable connector **300''** in which some embodiments of the present technology may be implemented. Connector **300''** is similar in many respects to connector **300'** of FIGS. 2C-2E, as indicated by similar numbering, and in some respects has been illustrated in less detail for the sake of brevity.

In particular, mating part **303''** is similar in many respects to mating part **103** of FIG. 1B, and mating part **302''** is similar in many respects to mating part **302'** of FIGS. 2C-2E, as indicated by similar numbering, and in some respects has been illustrated in less detail for the sake of brevity. As contrasted with mating part **302'**, mating part **302''** has notches **348''** that are more inwardly formed (vis-à-vis sidewalls **330''**) than are notches **348'** (vis-à-vis sidewalls **330'**). Gasket **350''** is similar to gasket **350'**.

FIG. 2G is a cross-section, and FIG. 2H is a top view of one-half, of a mating part **403** of another implantable connector **400** in which some embodiments of the present technology may be implemented. Mating part **403** is similar in many respects to mating part **203** of FIG. 2A, as indicated by similar numbering, and in some respects has been illustrated in less detail for the sake of brevity.

Mating part **403** further includes a protection structure **452**, e.g., a gutter, recessed into interfacing surface **442** and configured to protect interfacing surface **442** against contaminant intrusion. Gutter **452** is formed in, e.g., outer area **446** of interfacing surface **442**, and is located inwardly of sidewalls **430**. Gutter **452** is configured to enclose inner area **444** of interfacing surface **442**. While mating part **403** is decoupled from its corresponding mating part (not illustrated), gutter **452** protects inner area **444** of interfacing surface **442**, and thus electrodes **420** and **422**, from contamination by body fluids that otherwise might wash over sidewalls **430** of mating part **403**.

In FIG. 2H, mating part **403** is also illustrated with an optional groove **454** configured to extend from gutter **452** to sidewall **430** of mating part **403**. Groove **454** facilitates drain-

ing of gutter **452**, e.g., with assistance of a vacuum (negative pressure) from a surgical sucker **456**.

FIG. 3A is a three-quarter perspective view, and FIGS. 3B-3C are cross-sections, of a system **500**, in which some embodiments of the present technology may be implemented, for protecting an implantable connector against contaminant intrusion between mating parts of the connector. The mating parts of the connector of system **500** can variously be similar in many respects to the mating parts, e.g., of FIGS. 2A and 2F-2G, as indicated by similar numbering, and in some respects have been illustrated in less detail for the sake of brevity.

In FIGS. 3A-3C, system **500** includes an implantable connector having first and second detachable mating parts **502** and **503** configured to be implantable in living tissue and terminate a first segment **504** and a second segment **514** of a cable, respectively. Mating parts **502** and **503** have interfacing surfaces **540** and **542** bounded by sidewalls **530** and **531**, respectively. It is noted that FIG. 3C illustrates, e.g., a later stage in the context of the replacement scenario vis-à-vis FIG. 3B, wherein replace mating part **502** (illustrated in FIG. 3B but not in FIG. 3C) has been removed in preparation for subsequent re-coupling with a replacer mating part **502** (not illustrated). The various components of system **500** are formed of biocompatible materials, e.g., including one or more of Titanium, Silicone, Ceramic, Platinum, Platinum/Iridium, polyether ether ketone (PEEK), etc.

System **500** further includes a protection structure **560**, e.g., a hollow cylinder, configured to enclose one or more of sidewalls **530** and **531**. Cylinder **560** is formed with a slit **562** oriented substantially parallel to the axis of symmetry of cylinder **560**. Slit **562** is configured to receive segment **504** of the cable. For example, one end of cylinder wall **564** can have formed therein a notch **568** configured to receive segment **514** of the cable. Notch **568** and slit **562** can be located on substantially opposite sides of cylinder **560**. Wall **564** of cylinder **560** is further configured, e.g., to abuttingly enclose at least one or more of sidewalls **530** and **531**.

Cylinder wall **564**, e.g., has formed therein a notch **566** that can receive a gasket **550** that forms a seal between notch **566** and at least sidewall **531** of mating part **503**. Alternatively, notch **566** could be located such that gasket **550** also forms a seal with sidewall **530** of mating part **502**. Gasket **550** can be formed of a resilient material, a foam material or a viscous material, that deforms upon compression.

FIG. 3D is a cross-section of another system **500'**, in which some embodiments of the present technology may be implemented, for protecting an implantable connector against contaminant intrusion between mating parts of the connector. System **500'** is similar in many respects to system **500** of FIGS. 3A-3C, as indicated by similar numbering, and in some respects has been illustrated in less detail for the sake of brevity.

Mating parts **502'** and **503'** of connector **500'** have interfacing surfaces **540'** and **542'**, respectively. Each of interfacing surfaces **540'** and **542'** is arranged with an inner area **544**, e.g., a circular area. Interfacing surface **542'** is further arranged with an outer area **546'**, e.g., an annular outer area, that encloses inner area **544'**. Corresponding electrode pairs (not illustrated) are provided on inner areas **544'** of interfacing surfaces **540'** and **542'**. As contrasted with mating part **503** (vis-à-vis mating part **502**), mating part **503'** is wider than mating part **502'**, the extra width corresponding to outer area **546'** of interfacing surface **542'**. Ends of sidewall **564'** of cylinder **560** abut outer area **546'** of interfacing surface **542'**.

FIGS. 4A-4D are cross-sections that together illustrate another system **600** in which some embodiments of the

present technology may be implemented, for protecting an implantable connector against contaminant intrusion between mating parts of the connector. The mating parts of the connector of system 600 can variously be similar in many respects to the mating parts, e.g., of FIGS. 2A-2H and 3A-3D, as indicated by similar numbering, and in some respects have been illustrated in less detail for the sake of brevity.

In FIGS. 4A-4C, system 600 includes an implantable connector having first and second detachable mating parts 602 and 603 configured to be implantable in living tissue and terminate first and second segments (not illustrated) of a cable, respectively. Mating parts 602 and 603 have interfacing surfaces 640 and 642 bounded by sidewalls 630 and 631, respectively. Corresponding electrode pairs (not illustrated) are provided on interfacing surfaces 640 and 642. FIGS. 4A-4C assume that mating part 603 is partially recessed in bone 126. The various components of system 600 are formed of biocompatible materials, e.g., including one or more of Titanium, Silicone, Ceramic, Platinum, Platinum/Iridium, polyether ether ketone (PEEK), etc.

System 600 further includes a protection structure 660, e.g., a coffer dam, configured to enclose sidewalls 631 of mating part 603. Cofferdam 660 can be spaced apart from sidewall 631 so as to leave a gap 670 therebetween. Alternatively, coffer dam 660 can be arranged to abut sidewall 631.

Whereas mating part 603 is relatively durable, coffer dam is, e.g., relatively transitory. For example, coffer dam 660 can be formed of a resilient, foam and/or viscous material, e.g., that is bioresorbable.

FIG. 4A is illustrated at a time at which mating parts 602 and 603 have been provided and coupled but before coffer dam 660 has been provided. FIG. 4B is illustrated at a time that coffer dam 660 is partially formed. In FIG. 4B, a nozzle 672 is illustrated as providing source material for coffer dam 660. An operator can move nozzle 672 circumferentially around sidewall 631 as the material is being dispensed, thereby forming coffer dam 660.

FIG. 4C is illustrated at a time after coffer dam 660 has been provided to system 600, and further illustrates alternatively three stages in a procedure to replace an instance of mating part 602 (the “replacee” version of mating part 602) by another instance of mating part 602 (the “replacer” version of mating part 602) while mating part 603 remains in its implanted position. A first stage illustrated by FIG. 4C is denoted by arrow 674, and represents the “replacee” version of mating part 602 being decoupled from mating part 603. A second stage illustrated by FIG. 4C is denoted by arrow 676, and represents the “replacer” version of mating part 602 being re-coupled to mating part 603. A third stage illustrated by, FIG. 4C can be understood as illustrated at a time when mating parts 602 and 603 are in decoupled state before they are initially coupled (the initially coupling being noted by arrow 676). When mating part 602 is decoupled from mating part 603, a surface 642 of mating part 603 (on which the electrodes (not illustrated) are located) is placed at risk of contamination by body fluids that would otherwise wash over sidewalls 631 of mating part 603 if coffer dam 660 were not provided.

FIGS. 5A-5B are cross-sections of another system 700 in which some embodiments of the present technology may be implemented, for protecting a mating part 705 of an implantable connector against contaminant intrusion. Mating part 705 can variously be similar in many respects to mating parts, e.g., 102 and 103 of FIGS. of 1A-1D, 202 and 203 of FIG. 2A, 302 and 303 of FIG. 2B, 302' and 303' of FIGS. 2C-2E, 302" and 303" of FIG. 2F, 403 of FIGS. 2G-2H, 502 and 503 of FIGS. 3A-3C, 502' and 503' of FIG. 3D, and 602 and 603 of

FIGS. 3A-3D, as indicated by similar numbering, and in some respects has been illustrated in less detail for the sake of brevity.

In FIGS. 5A-5B, mating part 705 is configured to be implantable in living tissue and terminate a segment (not illustrated) of a cable. Mating part 705 has an interfacing surface 747 bounded by sidewall 733. Electrodes (not illustrated) are provided on interfacing surface 747 in correspondence to electrodes (not illustrated), respectively, on a corresponding mating part (not illustrated). Mating part 705 is formed of biocompatible materials, e.g., including one or more of Titanium, Silicone, Ceramic, Platinum, Platinum/Iridium, polyether ether ketone (PEEK), etc.

System 700 not only includes mating part 705, but also a protection structure 778 configured to protect interfacing surface 747 against contamination. For example, protection structure 778 includes a removable layer 778, e.g., a protective film, disposed in contact with interfacing surface 747 so as to seal the same from the ambient environment. Removable layer 778 temporarily adheres to interfacing surface 747, protecting it from contamination until mating part 705 is ready for coupling to a counterpart mating part, at which time the person intending to couple the mating parts, e.g., a surgeon, may remove layer 778. Optionally, layer 778 can include one or more portions that overhang one or more edges of sidewall 733 and thus serve as one or more tabs 779, each of which can be grasped and thereby used to exert a force on layer 778 by which to remove layer 778.

FIGS. 6A-6C are cross-sections of another connector 800 in which some embodiments of the present technology may be implemented. The mating parts of connector 800 can variously be similar in many respects to the mating parts, e.g., of FIGS. 1A-1D, 2A-H, 3A-D, etc., as indicated by similar numbering, and in some respects have been illustrated in less detail for the sake of brevity.

In FIGS. 6A-6B, mating parts 802 and 803 are configured to be implantable in living tissue, e.g., mating part 803 is configured to be partially recessed in bone 126, and terminate first and second segments (not illustrated) of a cable, respectively. Mating parts 802 and 803 have interfacing surfaces 840 and 842 bounded by sidewalls 830 and 831, respectively. Corresponding electrode pairs (not illustrated) are provided on interfacing surfaces 840 and 842. Connector 800 is formed of biocompatible materials, e.g., including one or more of Titanium, Silicone, Ceramic, Platinum, Platinum/Iridium, polyether ether ketone (PEEK), etc.

Mating part 803 includes at least one alignment projection 880 extending substantially perpendicularly from interfacing surface 842. Mating part 802 includes at least one alignment hole corresponding to the at least one alignment projection 880, respectively, each alignment hole 882 being complementarily shaped to receive corresponding alignment projection 880. The at least one alignment projection 880 also is formed of biocompatible materials, e.g., including one or more of Titanium, Silicone, Ceramic, Platinum, Platinum/Iridium, polyether ether ketone (PEEK), etc.

Recesses 882 are formed in alignment with associated projections 880 so insertion of alignment projections 880 into recesses 882 causes mating parts 802 and 803 to align, thereby facilitating a good electrical connections between electrodes of corresponding pairs thereof (not illustrated) provided on interfacing surfaces 840 and 842.

Optionally, each alignment hole 882 can extend through mating part 802 to form a through-hole in one or more opposing second surfaces 886 thereof. Each alignment projection 880 can include a portion 884 that stands proud of surface(s) 886 of mating part 802. Also, optionally, one or more proud-

11

standing portions **884** can be configured as a flange **888**. Each flange **888** and the corresponding hole **882** have a diameter extending in a direction substantially perpendicular to the long axis of the alignment projection, with flange **888** being wider than hole **882**. Flange **888** resists mating part **802** from a tendency (if any) to decouple from mating part **803**.

FIG. 7A is a top view, and FIG. 7B is a cross-section, of a machine **900**, in which some embodiments of the present technology may be implemented, for manipulating mating parts of an implantable connector. The mating parts of the connector that are manipulable by machine **900** can variously be similar in many respects to the mating parts, e.g., of FIGS. 1A-1D, 2A-H, 3A-D, 6A-6C, etc., as indicated by similar numbering, and in some respects have been illustrated in less detail for the sake of brevity.

In FIGS. 7A-7B, a first mating part **903** and first and second instances **902A** and **902B** of a second mating part are configured to be implantable in living tissue, e.g., mating part **903** being partially recessed in bone **126**, and terminate a first segment (not illustrated) and first and second instances **904A** and **904B** of a second segment of a cable, respectively. Instances **904A** and **904B** of second segment of a cable are connected to first and second instances **990A** and **990B** of another component.

First and second instances **902A** and **902B** of the second mating part **902A** and mating part **903** have first and second instances **940A** and **940B** of a second interfacing surface and a first interfacing surface **942** bounded by first and second instances **930A** and **930B** of a sidewall and a sidewall **931**, respectively. Corresponding electrode pairs (not illustrated) are provided on first and second instances **940A** and **940B** of the second interfacing surface and on interfacing surface **942**. The connector comprising mating parts **902A** and **903** is formed of biocompatible materials, e.g., including one or more of Titanium, Silicone, Ceramic, Platinum, Platinum/Iridium, polyether ether ketone (PEEK), etc.

Machine **900** includes an enclosure **992** and a coupling device **996**. Enclosure **992** is configured to releasably enclose at least first and second instances of mating part **902A** and **902B** and a portion of mating part **903** in an environmentally controllable volume **994**, e.g., a hermetically sealable volume. Enclosure **992** can be a multi-piece assembly. Coupling device **996** is configured to at least one of decouple and re-couple mating part **903** and instances **902A** and **902B** of the second mating part, respectively, while instances **902A** and **902B** of the mating part and the portion of mating part **903** are disposed in environmentally controllable volume **994**.

During operation of machine **900**, mating part **903** is stationary relative to instances of mating part **902A** and **902B**. Coupling device **996** includes: a decoupling apparatus **998** and a re-coupling apparatus **1000**. Decoupling apparatus **998** is configured to: decouple mating part **903** and instance **902A** of the second mating part; and move instance **902A** of the second mating part along an arcuate path **1002** away from mating part **903**. Re-coupling apparatus **1000** is configured to: move instance **902B** of the second mating part along arcuate path **1002** towards mating part **903**; and re-couple first mating part **903** to second instance **902B** of the second mating part. Coupling device **996** also can include, e.g., a cleaning apparatus **1002** configured to clean mating part **903** and instance **902A** of the second mating part. Cleaning apparatus **1002** can include: an irrigation apparatus **1004** to wash mating part **903** and instance **902A** of the second mating part; and a drying apparatus **1006** to dry mating part **903** and instance **902A** of the second mating part.

12

In FIGS. 7A-7B, there is a rotational axis **1008** about which the motion along arcuate path **1002** occurs. Decoupling and re-coupling is associated with motion along a coupling axis **1010**, where coupling axis **1010** is substantially parallel to but radially displaced from rotational axis **1008**. Machine **900** further includes a crankshaft **1012** that is coaxial with rotational axis **1008**. Coupling device **996** is mounted to crankshaft **1012**. More particularly decoupling apparatus **998**, irrigation apparatus **1004**, drying apparatus **1006** and re-coupling apparatus **1000** are mounted to crankshaft **1012**, via mechanisms **1014-1017**, respectively. Inducing rotation of crankshaft **1012** can cause instances **902A** and **902B** of the second mating part to be moved along arcuate path **1002** away from mating part **903**. Gaskets **1014** and **1016** make a seal between crankshaft **1012** and enclosure **992**. Gasket **1018** makes a seal between mating part **903** and enclosure **992**.

FIG. 7C is a cross-section of another machine **900'**, in which some embodiments of the present technology may be implemented, for manipulating mating parts of an implantable connector. Machine **900'** is similar in many respects to machine **900** of FIGS. 7A-7B, as indicated by similar numbering, and in some respects has been illustrated in less detail for the sake of brevity.

In FIG. 7C, there is a rotational axis **1008'** about which the motion along arcuate path **1002'** occurs. Decoupling and re-coupling is associated with motion along a coupling axis **1010'**, where coupling axis **1010'** is substantially orthogonal to rotational axis **1008'**.

The present technology described and claimed herein is not to be limited in scope by the specific example embodiments herein disclosed, since these embodiments are intended as illustrations, and not limitations, of several aspects of the present technology. Any equivalent embodiments are intended to be within the scope of the present technology. Indeed, various modifications of the present technology in addition to those shown and described herein will become apparent to those skilled in the art from the foregoing description. Such modifications are also intended to fall within the scope of the appended claims.

What is claimed is:

1. An implantable connector comprising:

a first mating part comprising a first interfacing surface and a first terminating segment of a communication cable; and

a second mating part comprising a second interfacing surface and a second terminating segment of the communication cable, wherein each of the first mating part and the second mating part are configured:

to be implantable in living tissue; and

to detachably mate at the first and the second interfacing surfaces;

and

a protection structure configured to protect against contaminant intrusion between the first and second interfacing surfaces.

2. The connector of claim 1, wherein:

each of the first and second interfacing surfaces has an inner area and at least one of the first and second interfacing surfaces has an outer area enclosing the inner area;

the first and second segments of the communication cable are connected to at least a first pair of contacts provided on the inner areas of the first and second interfacing surfaces, respectively; and

the protection structure is positioned in the outer area and is further configured to enclose the inner areas of the first and second interfacing surfaces, respectively.

13

3. The connector of claim 1, wherein:
the protection structure includes at least one of:
a gasket;
a wall projecting from one of the first and second inter-
facing surfaces; and
a gutter formed in one of the first and second interfacing
surfaces.
4. The connector of claim 3, wherein:
the protection structure includes the wall;
the wall projects from the first interfacing surface such that
the wall and the first interfacing surface define a recess in
the first mating part; and
the second interfacing surface of the second mating part is
configured in a shape of a complementary projection
sized to engage the recess.
5. The connector of claim 4, wherein:
the protection structure also includes the gasket; and
the gasket is disposed between the projection and the wall.
6. The connector of claim 4, wherein:
an inner area stands proud of an outer area of the first
interfacing surface; and
the gasket is disposed in a notch formed by the inner and
outer areas of the first interfacing surface; and
the gasket stands proud of the inner area of the first inter-
facing surface.
7. The connector of claim 3, wherein:
the gasket is an o-ring.
8. The connector of claim 3, wherein:
the gutter is formed in the first interfacing surface;
the first mating part has a sidewall intersecting the first
interfacing surface; and
the protection structure further includes:
a groove configured to extend from the gutter to the
sidewall of the first mating part and thereby facilitate
draining of the gutter.
9. The implantable connector of claim 1, wherein the pro-
tection structure is retained in a notch defined by at least one
of the first mating part and the second mating part.
10. The implantable connector of claim 1, wherein the
protection structure comprises a skirt projecting from at least
one of the first mating part and the second mating part.
11. The implantable connector of claim 1, wherein the
protection structure comprises a deformable element.
12. A system for protecting an implantable connector hav-
ing a first detachable mating part configured to be implantable
in living tissue and terminate a first segment of a communi-
cation cable, and a second detachable mating part configured
to be implanted in living tissue and terminate a second seg-
ment of the communication cable, each mating part having an
interfacing surface bounded by one or more sidewalls, the
system comprising:

14

- a protection structure configured to enclose the one or more
sidewalls of at least one of the first and second mating
parts.
13. The connector of claim 12, wherein:
the protection structure includes a hollow cylinder com-
prising a
cylinder wall having formed therein a slit oriented substan-
tially parallel to the axis of symmetry of the hollow
cylinder and being configured to receive the second seg-
ment of the communication cable; and
the cylinder wall is further configured to abuttingly enclose
at least the one or more sidewalls of the second mating
part.
14. The connector of claim 13, wherein:
each of the interfacing surfaces has an inner area and the
interfacing surface of the first mating part also has an
outer area enclosing the inner area; and
an end of the cylinder wall abuts the outer area of the first
interfacing surface.
15. The connector of claim 13, wherein:
the protection structure further includes at least one gasket
disposed between the cylinder wall and the one or more
sidewalls of at least one of the first and second mating
parts.
16. The connector of claim 13, wherein:
the cylinder wall has formed at one end thereof a notch
configured to receive the first segment of the communi-
cation cable.
17. The connector of claim 12, wherein:
the first mating part is configured so as to be recessed in the
tissue; and
the protection structure includes a coffer dam disposed on
the tissue and configured to enclose at least the one or
more sidewalls of the second mating part.
18. The connector of claim 17, where:
the first mating part is relatively durable; and
the coffer dam is relatively transitory.
19. The connector of claim 18, wherein:
the coffer dam includes at least one of:
a viscous material; and
a foam material.
20. The connector of claim 12, wherein:
the connector is a button type of connector.
21. The system of claim 12, wherein the protection struc-
ture is retained in a notch defined by at least one of the first
mating part and the second mating part.
22. The system of claim 12, wherein the protection struc-
ture comprises a skirt projecting from at least one of the first
mating part and the second mating part.
23. The system of claim 12, wherein the protection struc-
ture comprises a deformable element.

* * * * *